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FORTY YEARS OF REINFORCED CONCRETE*

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EDITOR'S NOTE:

This review indicates the general trend of concrete development during the past 40 years and shows the direction in which future progress must be made. The subject is treated in sufficient detail to be of interest to those with knowledge and experience of concrete work, while being simple enough to be followed by those with no such knowledge.

THE first essay in reinforced concrete construction at Tottenham was undertaken in the year 1911. Since that date Tottenham engineers have taken a continuous interest in the development of reinforced concrete as a medium of construction and, as the years have passed, considerable experience on this subject has been accumulated. The authors of this paper have served the Tottenham undertaking since the years 1920 and 1922 respectively and have been actively engaged upon reinforced concrete work from that time until the present date.

As an introduction to the subject, it is appropriate to refer to the first reinforced concrete structure built at Tottenham in 1911. This was a reinforced concrete roof to an underground liquor storage tank, over which was built a series of workshops. In the early 1920's this roof, or floor, showed signs of subsidence. This continued until the year 1947, when it was deemed advisable for the superimposed workshops to be demolished and the area railed off. Before the decision to close the area was made, a portion of the structure had been cut away and an examination made. This examination revealed a number of points which serve as a useful object lesson to introduce the subject of the use of reinforced concrete in gasworks.

The floor was constructed according to the ideas current in the year 1911 and consisted of a series of main beams supported on blue brick piers and connected by secondary beams supporting a slab 4 in. thick. The main and secondary beams were designed as Tee beams. The slab was reinforced with steel bars ½ in. square at 12 in. centres, having a ¾ in. cover on the underside. The design stresses employed were those currently adopted at that time—namely 16,000 lb./sq. in. of tension in the steel and 600 lb./sq. in. of compression in the concrete.

The underside of the slab was in contact with ammonia gas and the whole structure therefore formed an admirable test unit for the examination of the behaviour of reinforced concrete under the conditions applicable to a great many locations in a gasworks.

Early in the 1920's it was noticed that the walls of the superimposed buildings were cracking. These cracks denoted some subsidence in the main beams, so these were carefully watched. Although the subsidence increased slightly, no sudden movements were noticed and the structure was held to be still in a safe condition. About 1945 it was noticed that several of the panels were showing deflection, the centre of some panels being as much as 1 in. lower than the edges which lay over the main and secondary beams. It was then that a section of the floor was closed to traffic and a detailed examination made.

This examination showed two things—first, that in the centre of the floor slabs the reinforcement was still firmly embedded in sound concrete and that no deterioration either of concrete or steel had taken place, and, secondly, that at the abutments of the slab over the main and secondary beams deterioration of the concrete had taken place and half-inch square reinforcing bars had, in some places, been reduced to ⅜ in. × ¼ in. Examination of the original design revealed the cause of this failure. Fig. 1 shows a section of the slab and from this it will be seen that the quantity of steel reinforcement to take reverse bending over the supports is only half that at the centres of the spans. Had the slab been properly designed as a series of continuous beams, the reinforcement over the supports should have been considerably more than that at the centres of the spans. It was evident that overstressing of the steel had taken place over the supports with resulting cracking of the concrete. Liquor had penetrated at these points and both steel and concrete had deteriorated.

The examination of the structure was of particular interest to the authors as it vindicated the view that they had supported for many years—namely, that concrete of the right quality, properly laid and free from excessive tensile stresses liable to form hair cracks, gives adequate protection to reinforcing steel against ammoniacal liquor, and that reinforced concrete construction, provided stresses are properly limited, can be safely employed for gas and water tight vessels subject to attack from ammoniacal liquors.

The essential point in the design of concrete structures that have to contain liquids or are liable to corrosive attack is the elimination of cracks. In orthodox concrete design it is usual to allow tensile stresses in the steel up to 18,000 lb./sq. in. As the ratio of the elastic moduli of steel and concrete is as

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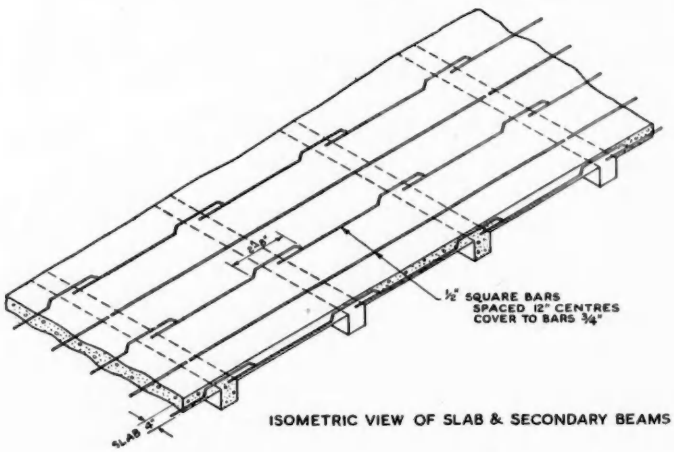
15 to 1, the resulting tensile stress in the surrounding concrete will be about 1,200 lb./ sq. in. The concrete is unable to withstand this tension and hair cracks result. These cracks are accepted in normal concrete construction and they in no way endanger the strength of the structure. Where the storage of liquids is involved, however, such cracks must be avoided.

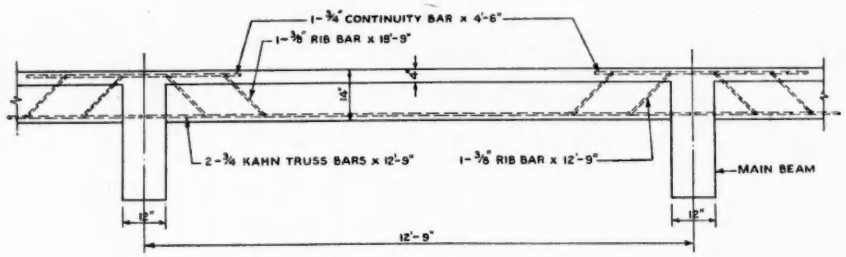
In the year 1938 the Institution of Civil Engineers brought out recommendations covering the design of concrete vessels intended for the retension of fluids. The essential theme of these recommendations is that the tensile stress, induced by bending, should be limited, in the case of any face exposed to the liquid, to 250 lb./sq. in. in the concrete and 3,000 lb./sq. in. in the steel. These values are based on a modular ratio of 12 to 1, which is the ratio applicable to the higher grade of concrete which would normally be employed for this class of work.

ground tar and liquor storage tank recently constructed at Ponders End works. A cross section of the tank is shown in Fig. 2. It should be noted that in this design both main and secondary roof beams have been dispensed with. The roof load is carried on the two outer walls and four intermediate walls, all of which are continuous. Three of the intermediate walls are pierced to permit the passage of liquids, and the fourth is solid, dividing the tank into two sections. The roof is in one slab of uniform thickness, designed as continuous over the five spans. This slab is 18 in. thick. In producing this robust design, advantage has been taken of the fact that a certain minimum mass of concrete was required to prevent the tank from floating when empty. It is not anticipated that there will be any repetition of the failure experienced in the case of the 1911 tank.

An interesting, though minor, development of concrete is the



ISOMETRIC VIEW OF SLAB & SECONDARY BEAMS



ELEVATION OF SECONDARY BEAM

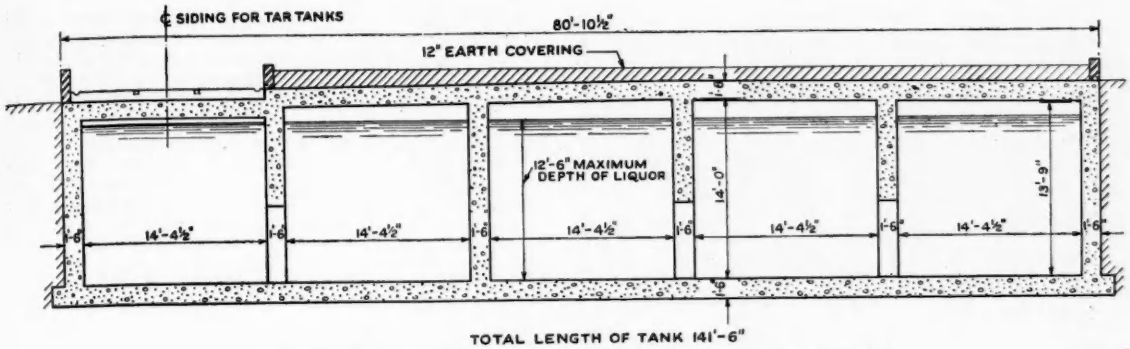
Fig. 1

As the years have gone by, engineers engaged upon concrete construction have paid increasing attention to the quality of concrete employed. It was not until the 1930's, however, that it was generally appreciated that concrete of a much greater strength than had previously been used could consistently be obtained by the careful control of construction processes. The use of carefully washed and graded aggregates, the control of surplus water, care in placing and consolidation of the mix, coupled with continuous supervision by competent engineers and the regular casting and testing of samples, showed that working stresses up to 1,000 or 1,200 lb./sq. in. in compression could be regularly used in normal reinforced concrete work. This is to be compared with the old standard of 600 lb./sq. in. The stronger concrete thus obtainable was also, without question, more resistant to the penetration of fluids. This, therefore, was an additional factor in the satisfactory development of reinforced concrete for the construction of vessels to contain fluids and gases.

Reference has been made to the failure of a roof over a liquor well. It is interesting, in contrast, to describe an underconstruction of brine tanks for use with base exchange water softening plants. Corrosion had always been heavy with both steel and cast iron tanks and to avoid frequent renewals an experimental tank was constructed in concrete. This was designed in accordance with the 1938 I.C.E. Code and no special treatment or lining was employed. This tank has been in use since 1941 and has shown no sign of deterioration. Several other tanks have since been constructed for the same purpose.

Purifier Boxes

One of the main uses to which reinforced concrete has been put in gasworks is the construction of purifier boxes. The first concrete boxes built at Tottenham were constructed in 1916 and it is believed these were the first boxes of this type to be constructed in this country or anywhere else. These boxes are still at work after 34 years' service and although repairs have from time to time been found necessary, they are still structurally sound. They were, of course, designed to the steel and concrete stresses common to all concrete structures



SECTIONAL ELEVATION OF TAR & LIQUOR STORAGE TANK

Fig. 2

at that time, no attempt having been made to reduce the tension in the concrete faces exposed to the interior of the boxes. As might be expected, they have suffered in the same way as the floor slab already referred to. Cracks occurred in the floor slab adjacent to the main beams exactly as in the previous case, and liquor percolated through the slab and ran down the sides of the beams beneath. Hair cracks in the soffits of these beams, which otherwise would have caused no trouble, attracted the liquor and allowed it to penetrate to, and attack, the main reinforcing bars. The result was the formation of a swelling scale on the steel which, in turn, broke away the covering concrete and exposed the whole of the main reinforcing steel to further attack. A photograph of the underside of these boxes is shown in Fig. 3.

Fig. 3

Extensive repairs were carried out to the main beams of these boxes in 1945 and they are now structurally safe, although the design in no way complies with present-day standards. A photograph of the beams, after repair, is shown in Fig. 4.

A similar and smaller set of boxes was built at Ponders End works in 1920 and the same design was employed. These boxes are still standing and were in use until two years ago.

In 1928 a further installation of 15 boxes was constructed. These measured 25 ft. x 32 ft. each inside and there were three parallel rows each of five boxes. They were provided with an overhead revivifying floor and the whole structure measured approximately 130 ft. x 125 ft. In the light of present knowledge it would today be deemed extremely foolish to build boxes in this manner. The stresses employed were still such as to allow the formation of hair cracks and panel and Tee beam construction was still adopted. It was realised that in a structure of this size expansion troubles would arise and an attempt was made to overcome these by predetermining the point at which expansion cracks would occur. A specially weak section was made at these points, and rebates were formed which were filled with what was intended to be a plastic sealing joint. The result was not entirely successful. One of the chief difficulties was in obtaining a sealing compound that would be immune from attack by corrosive liquors. The boxes, however, are still in use, and although this type of design would not be advocated nowadays, the boxes still have many years of life before them.

In 1939 a single row of 30 ft. square boxes was built and these, in general, embodied the principles now adopted. All forms of secondary beam construction were abandoned and concrete was used much more liberally than in the previous

Fig. 4

designs. Five boxes were constructed in a single row, end to end. Solid wall and slab construction were used throughout and all slabs and walls were made to a uniform thickness. Expansion and contraction could therefore take place throughout the whole length of the structure and as all sections were of the same thickness, the secondary stresses were largely eliminated. Tensile stresses in the steel and concrete were limited to those recommended in the 1938 I.C.E. Code, so that hair cracks in the faces would not be formed. These boxes have been in use for 10 years and have shown none of the signs of deterioration evident in earlier designs. The current practice is to construct boxes of this design always in single rows with the boxes end to end. A recent example of this is in the installation completed at Ponders End since the war. Here there are four independent rows each of five boxes, 30 ft. x 30 ft. each, with an oxide floor covered by a spanned roof in the space between the two centre rows. A photograph of this installation is shown in Fig. 5.

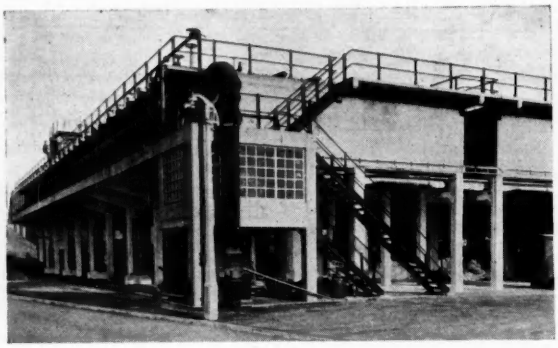


Fig. 5

In addition to what has already been stated concerning the construction of concrete purifiers, the following points should be noted:

1. The foundations should be entirely adequate to sustain the superimposed loads without uneven settlement. It is obvious that no system of boxes can be expected to remain free from cracks if subjected to secondary stresses not provided for in the design.
2. In common with the best modern concrete work, the form of the structure should be such that splays, changes in section, and other items requiring intricate shuttering, are eliminated. It is usually cheaper to employ rather more concrete than the necessary minimum, than it is to construct complicated formwork. The latter only impedes the satisfactory filling of the concrete. Moreover, the absence of splays and ornament undoubtedly gives the design a sounder and more robust appearance.
3. Every box, as soon as the concrete has hardened sufficiently to bear the load, should be filled with water. This action has a beneficial effect on the curing of the concrete. It must be remembered, however, that the structure must be designed to withstand this water loading as an alternative to the normal gas loading. In addition to this filling with water, the greatest care must be taken in hot or drying weather to keep the exterior faces of the boxes in a moist condition.

Though not strictly a matter of concrete construction, some description of the ironwork found suitable to concrete boxes is worthy of attention.

At Tottenham, since the year 1928, the design of covers and holding-down bolts has been standardised. Many designs of purifier cover, examined in the past, have been found to be structurally unsound, and it is apparent that it was a common practice to rely on a horizontal restraining force from the curbs of the box to balance the tension from the curved sheeting. These horizontal forces, combined with the vertical forces restraining the upward lift of the cover, produced oblique forces in the holding-down bolts. It is not considered that such a system is satisfactory and all covers at Tottenham have been designed as self-sustaining slabs that can be held in position by vertical forces only. The covers are slightly cambered to drain off moisture and the sheeting is supported by secondary Tee beams below and R. S. J. main beams above. The greater part of the load is taken by the main beams, which are held down by eyebolts swivelling on shanks embedded in the concrete. Intermediate to these main holding-down bolts are swivel bolts of a special design. These carry an eccentric but much lesser load and serve mainly as tacking bolts to secure contact between the cover and the curb of the box. These bolts are precision made and lubricated through grease nipples. The covers and bolts are to be seen in the photograph Fig. 6. Since 1928 it has not been necessary to renew a single one of these bolts.

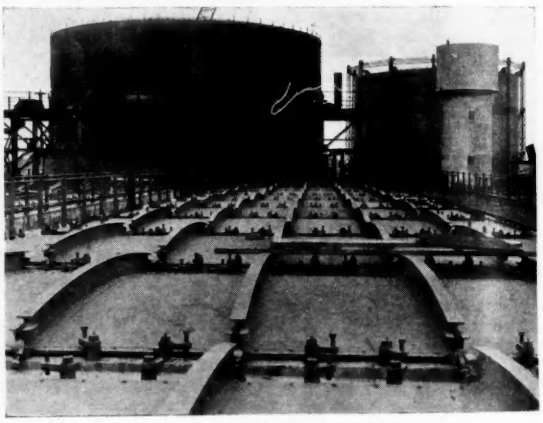


Fig. 6

The design of gas connections is a matter to which considerable thought has been given. It has been the practice at Tottenham to adopt the usual 'inlet, outlet, and by-pass' system

TABLE I

CONCRETE AND STEEL STRESSES FOR REINFORCED CONCRETE STRUCTURES SHOWING INCREASE DURING PAST 40 YEARS IN PERMISSIBLE VALUES

CODE	MIX	Stresses in lb. per sq. in.			Economical % of Steel Bending
		Concrete		Steel	
		Bending	Direct	Bending	
L.C.C. Regulations Period – 1934	4 - 2 - 1	600	600	16,000	0.67
Code of Practice recommended by Reinforced Concrete Structures Committee of the Building Research Board 1934	4 - 2 - 1	750	600	18,000	0.8
Code of Practice for the Design and Construction of Reinforced Structures for the Storage of Liquids recommended by the Institution of Civil Engineers 1938	4 - 2 - 1	880	880	12,000	1.72
British Standard Code of Practice C.P. 114 1948 for Normal Reinforced Concrete in Buildings	4 - 2 - 1	1,000	760	18,000	1.26

with entry at the sides of the boxes. Systems employing double valves of patented design have been used as well as those employing single valves of standard type. It is now the practice to use flexible joints liberally in the gas connections. Every gas entry to a box is provided with a Johnson flange adaptor located between the box and the valve, so that a complete air break can be obtained by sliding back the joint. Flexible joints are also necessary to provide for the differential expansion between the concrete boxes and the longitudinal mains and these are inserted at each side of each group of inlet, outlet, and by-pass valves.

Recent Developments

Mention has been made of the research which has been carried out over the past years resulting in higher working stresses for compression in concrete. Table I shows the values which have been allowed from time to time and the authority concerned. It will be noticed that as the stress in the concrete is raised the economical percentage of steel to take care of tension stresses is considerably increased. The effect of increasing the compression stress is to decrease the depth of concrete and this means that more steel is required to take care of sheer stresses. It may be said that the quantity of steel needed in reinforced concrete work is approximately proportional to the square of the compression stress in the concrete.

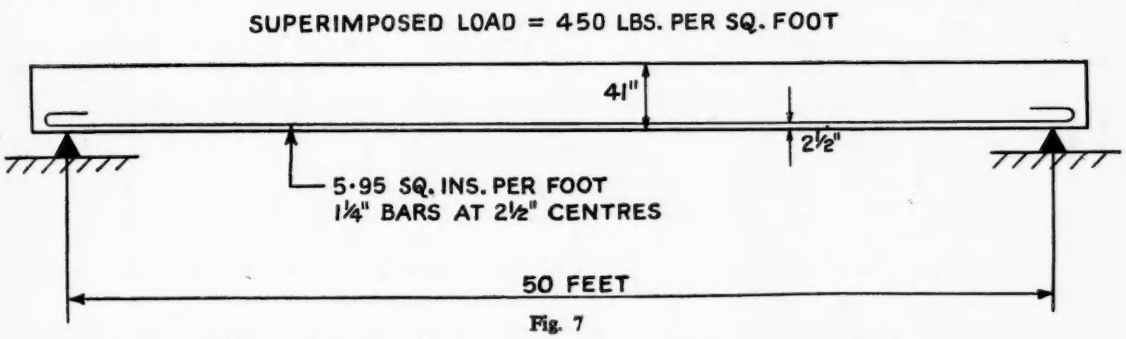


Fig. 7

It is rather surprising that the British Standard Code of Practice 1948 was introduced at a time when there was a shortage of steel. At Tottenham, all reinforced concrete, other than tank construction is designed to the 1934 Code either using a concrete stress of 750 lb./sq. in. or 850 lb./sq. in. according to whether ordinary or high grade concrete is specified. It must be remembered that the British Standard 1948 Code relates to normal reinforced concrete in buildings and is not recommended for structures of a specialised nature. Care must also be taken when using this Code that there is sufficient space to accommodate the quantity of steel and leave clearance between bars to allow concrete completely to surround the steel without leaving voids.

High grade concrete made with a correct water/cement ratio and well compacted will have a crushing resistance equal to 5,000 to 7,000 lb./sq. in., but it now seems that the limit of stress has been reached in so far as reinforced concrete is concerned. Any further increase to the compressive stress will mean an unworkable quantity of steel to take care of the tension stresses.

Prestressed Concrete

Progress, however, may still be achieved not by the consideration of two materials, concrete and steel, used in conjunction with each other, but by the consideration of concrete alone, overcoming its weakness in that it cannot sustain a high tensile stress. Prestressing concrete is a method whereby advantage is taken of the high value of resistance to compression without any of the concrete fibres being subjected to tension when under load. It is achieved by introducing initial compression to a member so that the application of an external load, while reducing this compression, will not induce tension stresses in the concrete.

Prestressed concrete is not a new idea or invention as the subject was investigated some 84 years ago. The early investigators were, however, not in possession of the facts regarding the behaviour of concrete under load and attempted to prestress concrete with mild steel. It was not until 1928, when a French engineer, Eugene Freyssinet, carried out research on the behaviour of concrete subjected to load, that progress could be made. The research proved that the compression of concrete results in a shrinkage additional to that normally to be expected by consideration of its elasticity. This additional shrinkage is termed creep. The early investigators, not knowing of this loss, attempted to prestress concrete with mild steel but found that after a few months the tension applied to the steel had disappeared.

The remedy for this serious drawback was the introduction of high tensile steel wire to replace the mild steel rods which gave the pioneers so much concern. The important characteristic of high tensile cold drawn steel wire, which is the material used for all prestressed concrete today, is that it can be stressed up to high values and thus give a high strain.

For example, a mild steel bar of 50 ft. in length as used in reinforced concrete, if stressed to 18,000 lb./sq. in. will stretch 0·36 in. A high tensile wire of the same length stressed to 120,000 lb./sq. in. will stretch approximately 2½ in. A concrete section of similar length—*i.e.*, 50 ft.—will shrink roughly 0·20 in. after prestressing is established, and after a few months

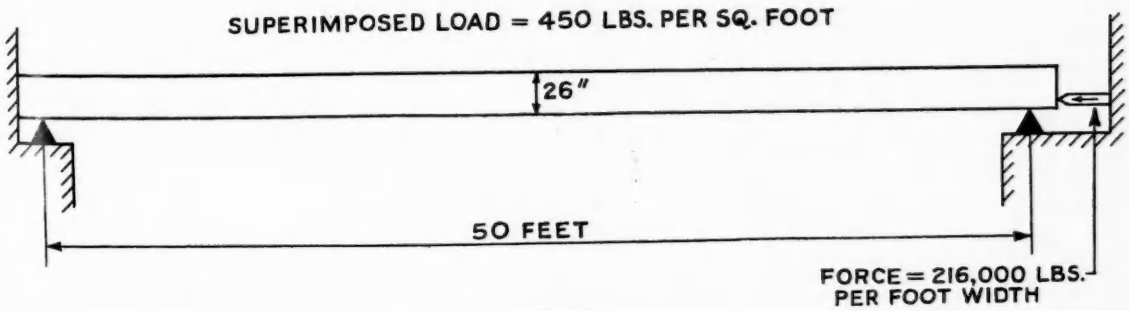


Fig. 8

another 0·20 in. is lost because of the creep of the concrete. It is seen that only by employing high tensile steel is it possible to make a permanently prestressed concrete member because in this case the extension induced in the wire is far in excess of the losses which must be accepted.

To illustrate the application of prestressed concrete it is best to turn to a practical problem. Let us consider a slab bridge of 50 ft. span loaded to 450 lb./sq. ft.

First we will design this slab in reinforced concrete, using stresses of 1,000 lb./sq. in. in the concrete and 18,000 lb./sq. in. in the mild steel (Fig. 7). On this basis the slab will have an overall thickness of 3 ft. 5 in. and will require 5·95 sq. in. of steel per ft. width of beam, or, in other words, 1¼ in. dia. bars spaced at 2½ in. centres.

Now let us consider the bridge slab built on a site where the abutments are of solid rock (Fig. 8). Between the abutments an unreinforced concrete slab 2 ft. 2 in. thick is cast on shuttering tight against the rock face at one end and with a space of some 2 ft. at the other end. When the concrete has hardened sufficiently, a hydraulic jack capable of applying a load of 100 tons is introduced into this space. The jack is arranged to apply the force at the end of the beam 3½ in. above the base of the beam.

shown by E. Again it should be noted that the whole of the section is in compression.

Few engineers are able to build on rock foundations and of course it would not be wise to rely on a hydraulic jack to provide the prestressing force.

We will therefore consider a design in concrete, prestressed in a practical manner, by the use of high tensile steel wire. As mentioned, this steel will have a working stress of 120,000 lb./sq. in. and to apply the force equal to that given by the hydraulic jack some 2·05 sq. in. of steel will be required. This figure is about 15% higher than is necessary by computation to cover the losses due to creep and shrinkage of the concrete. The final stress in the steel will be approximately 105,000 lb./sq. in. (Fig. 10).

A suitable wire to use would be 0·2 in. diameter and 66 wires of this diameter will be needed. These wires would be made up in two cables each of 33 wires placed side by side with the centre of the wires 3·65 in. above the bottom of the beam. The diagrams (Fig. 9) showing the stresses for the beam to be prestressed by means of a jack also apply to the beam prestressed with steel wires, as the conditions are exactly the same.

It will be observed that the prestressed concrete slab is only 26 in. thick, whereas a thickness of 41 in. was required for the

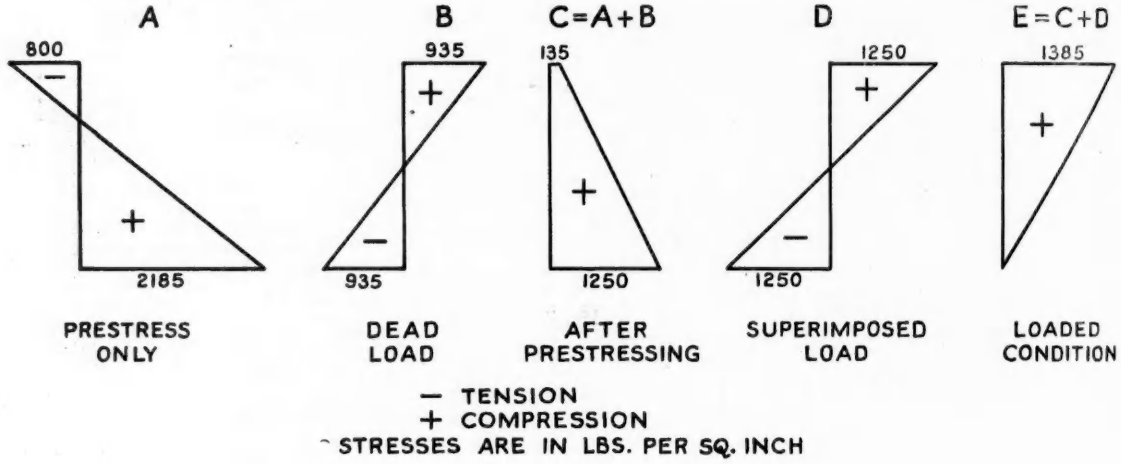


Fig. 9

Fig. 9 shows the analysis of the stresses in the centre of the beam under this condition and with the same loading as for the reinforced concrete beam. A is the stress diagram for the prestressing force alone; the tension in the top is caused by the eccentricity of the force. This condition will tend to bend the beam upwards. B is the stress diagram for the dead load alone and since the prestressing force and the force of the dead load act simultaneously, diagrams A and B must be added together and C is the result. These C stresses are the actual figures after prestressing and it is noted that the whole of the section is in compression. D is the stress diagram for the superimposed load and when this is added to C the result is

reinforced concrete slab. The area of steel is also reduced from 5·95 sq. in. in the case of the reinforced concrete design to the 2·05 sq. in. needed for the prestressed concrete design.

A detailed description of the methods used for tensioning the steel cables and the means of anchorage would fill a separate paper and the authors propose only to give a brief outline of the principles relating to the methods which are used.

There are two basic systems of prestressing, one used for shop precast work which may be termed the bonded wire method and the other used on site work, known as the non-bonded wire system or post-tensioning method.

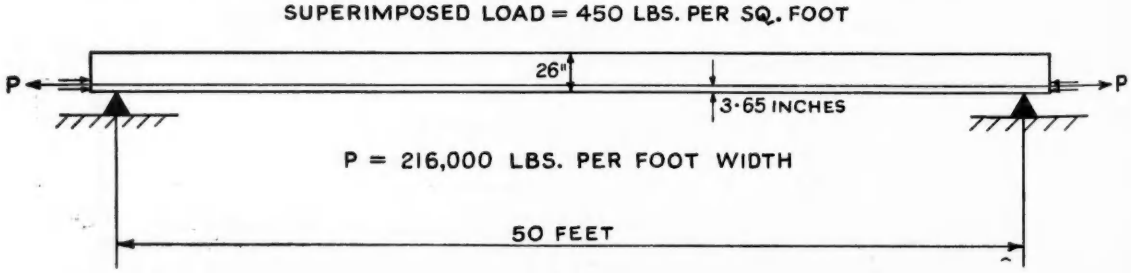


Fig. 10

The bonded wire system, sometimes known as the Hoyer system, consists of wires stretched between two fixed anchorages set in the shop floor anything up to 500 ft. apart. The wires pass through moulds and are spaced according to the shape of the members to be made. Usually a series of moulds is placed end to end with a space of about 12 in. between. After the wires are stretched concrete is poured into the moulds and vibrated. The concrete is then allowed to harden and when it has reached a predetermined strength the wires are released. The wires try to return to their original length but cannot since they are held by the concrete and thus the concrete is compressed.

Non-Bonded Wire System

There are two main applications of the non-bonded wire system, one evolved by the French engineer M. Freyssinet and the other by Professor Magnel, of Ghent University. Naturally the first method has been used extensively in France and the second has been widely used in Belgium and Holland. Both systems are being used in this country. The important differences between the two systems lie in the arrangement of the steel wires forming the prestressing cable, and in the means of anchorage. In both methods the tensioning of the wires is carried out after the concrete member is cast and hardened. The wires are anchored at one end into the concrete and at the other end are pulled by a jack acting against the end of the member. With the Freyssinet system the cables are either passed through cored holes in the concrete or are placed in their correct position before concreting, in which case they are wrapped in a thin steel sheathing. The jack used is a special double-acting machine able to stretch up to 18 wires and at the same time force home a tapered cone to anchor the wires securely.

In the Magnel system cables are built of wires in a series of sets of four, the wires being maintained about $\frac{3}{16}$ in. apart by means of grills and spacers arranged at intervals. The cable is inserted in the concrete after the member is cast and is passed through a cored rectangular hole. The hole is formed by means of a rubber core which is easily withdrawn after the concrete has partially hardened. A simple jack is employed for tensioning and the end anchorages consist of plates known as sandwich plates in which tapered grooves are machined to accommodate the wires. Steel wedges are hand driven into slots and when driven home anchor the wires.

In both systems the cables are pressure grouted after tensioning to prevent corrosion.

Hair Cracks

Mention has been made of the hair cracks which occur on the tension side of normal reinforced concrete members. The reason for these cracks may be explained if we consider the slab designed in reinforced concrete (Fig. 8).

The mild steel reinforcing bars 50 ft. long will have an extension of 0·36 in. when under a stress of 18,000 lb./sq. in. Concrete breaks under tension at an elongation of 0·12 in. in 50 ft. and with the steel bonded to the concrete it is obvious that the concrete will have cracked long before the steel is carrying its working load.

This fact is of particular importance to gas engineers, as structures at gasworks are often in a corrosive atmosphere. A familiar sight is the breaking away of concrete from a structure and the exposure of reinforcement. The reason for this condition, as in the case of the liquor storage tank and purifiers taken earlier as illustrations of concrete construction of 30-40 years ago, is that cracks due to tension in the concrete have allowed moisture to enter and cause corrosion of the reinforcement.

The stress diagrams of the slab already considered showed that when a prestressed concrete member is fully loaded no fibres in the concrete are subject to tension. There is, therefore, no reason for the concrete to crack.

The implication of this is that prestressed concrete, by its very nature, is more suitable than normally reinforced concrete for use in corrosive atmospheres and for the containing of fluids. Whether it is capable of practical and economic development for every type of structure remains to be seen. Already, prestressed concrete has been used extensively, both on the Continent and in the U.S.A., for the construction of bridges and framed buildings. In the U.S.A. an ingenious system of tank construction has been developed and circular tanks up to 150 ft. in diameter have been built. A concrete shell is first constructed and the prestress is obtained by winding steel wire around it under a constant tension. The operation is analogous to the winding of thread on to a bobbin. A special machine carries out this operation at great speed. This method of construction is particularly adaptable to gasholder tanks and the authors have investigated the system with a view to its use in this field.

In France a rectangular overhead storage reservoir has been successfully constructed and there would appear to be no reason why the principles of the design should not be applied to such structures as purifier boxes.

In this country the emphasis, so far, has been mainly upon precast work. Systems have been developed for the economical manufacture of railway sleepers, lamp columns, trestle poles, &c. Such other construction work as has been undertaken has largely been executed in accordance with continental practice. It must be remembered that the necessary experience for carrying out prestressed work is not yet widely dispersed in this country. A number of contracting firms are, however, taking a keen interest in the subject.

DISCUSSION

Mr. **G. Dougill** (North Thames Gas Board, Beckton) congratulated the authors on bringing forward a paper on reinforced concrete, because in spite of the large amount of experience gained of it it was still a subject which well repaid discussion and the pooling of ideas, as they were by no means near the end of improved technique in the construction and use of the material. Reinforced concrete was a building and constructional material that had come to stay, though its use in unsuitable cases had caused a certain amount of disappointment. While agreeing generally with all that was in the paper he would like to divert a little from the views expressed by the authors, who had confined themselves largely to troubles caused through incorrect design in the early days, and stress the other side of the picture, namely, the more personal problem of ensuring that all parts of a concrete structure should be equally, accurately, and conscientiously mixed and placed. They had implied that the biggest problem was design. No doubt correct design was very necessary, but the user found that the biggest problem of reinforced concrete was the personal one; on that side there was greater scope for personality than there was in the erection of a steel structure.

Speaking purely from the point of view of Beckton, they had had no substantial failure of any reinforced concrete structure due to design, but they had had quite a bit of trouble with the older structures due to cracking and spalling of the surfaces. There was little doubt that the cause was different from that expressed by the authors; that in fact in the 1910-20 era it was caused by overloading and the use of very skinny concrete. There was no doubt a large amount of trouble due to surface spalling, and it was not easy to repair. The authors emphasised the detrimental effect of hair cracks in heavily stressed structures due to tension, but in most cases surface cracks could have three main causes— insufficient cover particularly due to movement or incorrect position of the bars; slightly porous or defective concrete; or construction joints. In the case of Beckton they had increased the cover to allow for faults and emergencies, and there was no doubt they had achieved satisfaction. The personal side was very much more important in concrete than in the case of steel. With a faulty steel structure they could take out, say, 200 rivets and replace them and get a good structure, but once they got a flaw in a reinforced concrete structure they could not replace it. In the erection of a big structure employing every modern convenience, if the foreman's attention was distracted even for a short time they were liable to get a faulty bit of concrete. He felt he was not really disagreeing with the authors but emphasising another side of the problem which to his mind was no less important.

In addition to increasing the cover they were now developing ideas of applying inhibitors to the steel and the concrete in contact with it to reduce the effects of exposure and increase the margin of safety. All such experiments to be successful must extend over a period of up to 20 years, but accelerated

tests showed distinct promise. The authors had mentioned the repair of purifier beams but had omitted to say how this was done. So far they had found no method of repair which had produced more than limited success. It would be interesting to have details of the method used and the length of time which had elapsed since the work was carried out. Beckton had a battery of 32 purifiers which were put in in 1930, and in spite of vibration caused by many near misses with bombs they were still in almost perfect condition, and were a good example of what could be done by careful and conscientious work.

Three methods of repairing purifiers had been tried, namely, (1) where the whole surface required protection after a long life, by the removal of all loose material, cleaning and picking the surface, pegging B.R.C. mesh, and applying a new face; (2) by similar treatment but trowelling the material; and (3) by cutting out sections, repairing reinforcement, and replacing concrete. In conclusion he called attention to a way in which reinforced concrete could be used to great advantage, and that was where it was used for buildings in which the skeleton was of reinforced concrete panelled and cased in brickwork. This could produce a building with extremely low maintenance cost and which took advantage of the best points of all types of constructional materials.

Practical Considerations

Mr. **W. H. White** (Chief Engineer's Department, North Thames Gas Board) said a historical survey of most subjects was always worth while because it gave opportunity to review them in their true perspective. In these days one could get lost in a maze of complex details and miss the main objectives. He approached the subject of reinforced concrete from the point of view of the man in the field rather than from the design or æsthetic angle. He was particularly interested in the liquor storage tank episode related by the authors in which it was found that steel reinforcement had corroded to the extent of some 64% of cross section in 34 years. Under such conditions and considering the period in which the tank was built the results were impressive, to say the least. Reinforced concrete tanks for the storage of hot tar and liquor had been used by the former Gas Light and Coke Company for many years. During the war a particular tank was bombed and a detailed examination revealed no corrosion at all to the steel after 14 years' use. Numerous examples of a similar nature could be given; on the other hand one could cite very many examples of an opposite kind.

To establish a sense of values of the past they should remind themselves of certain facts: (a) cements were capable of solidifying when in contact with water without perceptible change of volume or notable evolution of heat; (b) hydraulic cements and limes possessed the power of solidifying under water; (c) the energy of a cement depended on the rapidity with which lime and silica or lime and alumina combined in the presence of water to form stable compounds, or when the ready formed silicates or aluminates became hydrated when water was added. Portland cements depended for their induration on a rearrangement of the silicates. For close on 2,000 years from the times of the Romans to Smeaton in 1756 no substantial advance was made in the employment of limes and cements. Smeaton first introduced an admixture of clayey matters admixed with calcined lime. Portland cement was first made by Joseph Aspdin, a Leeds bricklayer, in 1824, from a mixture of lime and clay. The choice of the name was due to its resemblance in colour and texture to the oolitic limestone of Portland.

Site Control and Quality

Records of some early tests were interesting. In 1852 the crushing strength of 1:3 cement and sand at the age of 52 days was 691 lb./sq. in. In 1886 the crushing strength of 1:2 cement and sand after three months was 2,717 lb./sq. in. A specification for Portland cement in 1882 required the cement to weigh not less 112 lb./bushel (equal to 1·28 cu. ft.). Present day standards were taken as 1·25 cu. ft./112 lb. It was stipulated that 90% should pass through a 50 mesh sieve and that the cement should bear a strain of 350 lb. at seven days. The first British Standard specification for cement was issued in 1904 and the latest in 1947. A study of these specifications told the story of continued progress in manufacture, an ever-increasing fineness of grinding, and extension in the control of purity, &c. Parallel with the progress in Portland cement the selection of fine and coarse aggregates had advanced until at the present time they had a more thorough knowledge due to comprehensive site surveys of deposits and physical characteristics.

Regarding site control and quality of materials, he suggested that grading and shape of aggregate was more important than physical properties. The use of rounded aggregates had increased the strength of concrete by nearly 100% over that of crushed stone. Influence of weather conditions, water/cement ratio control by slump test, bulking effect of fine aggregate and adjustment, bearing in mind that excess sand decreased workability and necessitated additional water, test cubes, inspection of placing reinforcement, form work, placing of concrete, and curing were all factors in the production of sound results, but in themselves they were insufficient, because it must be borne in mind that errors crept in, in spite of vigilance.

The power of adhesion of Portland cement to an aggregate was not yet fully understood. Errors with cement, even when weighed, could be of the order of plus or minus 1%. With fine aggregate there could be a plus or minus variation of 20% in bulk density; with coarse aggregate there could be a plus or minus variation of 3% in compaction. With test cube results, errors due to cement quality variation, faulty sampling, curing, &c., results could show a 40% variation, half of that amount being due to variation in the quality of the cement, the cement being at its minimum value above the British Standard requirements, and all this with strict site control and with laboratory technique employed in the field. Effects on the final structure due to temperature variation alone were most important, and it was well to bear in mind that expansion of concrete due to annual thermal variation was of the order of half an inch per 100 ft., and due to moisture variation about half that quantity. If only they could concrete in a temperature of the average for the year their results might be improved, but of course that was impracticable.

Attempts were constantly being made to reduce these errors. For example, an important feature, the workability factor, was being dealt with by the use of an apparatus called a concrete consistometer, in which a weighted ball was vibrated into a mix, the measure of the number of vibrations being the control. The workability factor was also being obtained with a lower water/cement ratio by the use of wetting agents which delayed the formation of gels on the cement grains and thereby left more water for lubrication of the mix. Too much added, however, could delay the setting time for several days, with disastrous results. The workability factor could be aided by vibration. Here again a word of warning was necessary, particularly with the immersion type. Skilled personnel was required because more harm than good could be done. Cement and sand would draw away from the coarse aggregate, and vibration transmitted along the reinforcement could cause pockets.

Curing Methods

Curing methods were important, but continued wet conditions involved labour difficulties, to say the least. A balance of these factors had to be made; very often one could cite an equal number of disadvantages and advantages. The effect of cover to reinforcement had been, and still was, an important factor to be reckoned with. Certain early structures had only half inch cover; this was later increased to 1¼ in. on main bars, and later still to 2 in. cover on main bars. Structures with small or faulty cover had been very troublesome. The technique of repairing these faulty structures was improving, and in his opinion the Continental practice of primary splash coat rendering was superior to most other methods.

Bonding of new concrete to old required a special technique and must not be dismissed lightly. Regarding the effect of heat on concrete, dehydration of concrete began at about 300°C. and was complete at 500°C. They had had some very unpleasant experiences due to that fact and costly remedial measures had had to be undertaken. For protection of reinforced concrete structures submitted to intense dry or wet heat in quenching towers they had carried out certain experiments using vermiculite mixed with Portland cement sprayed on to surfaces requiring protection, and so far the results had been very encouraging.

Prestressed concrete had been employed by the former Gas Light and Coke Company in the form of piles, precast standards, and in certain major repairs to foundations, where cables 100 ft. long transmitting a compressive strength of some 420 tons per cable were employed. Personally he felt a cautious approach was desirable in selecting it for use. Demolition of reinforced concrete structures and formation work in existing structures had in the past been difficult but they had been aided considerably by the use of the oxygen lance.

On the subject of impact on concrete little was known, but he believed an extensive research on the subject was being planned. He was of the opinion that further advancement would be made in proportioning concrete on the basis of the surface area of the materials used. The welding technique of

(*Continued on p.* 668)

CARBONISATION IN CONTINUOUS VERTICAL RETORTS

The following is a report of the discussion on the paper by J. M. Brown, B.Sc., Assoc.M.Inst.Gas E., (Engineer, Saltley Gasworks, Birmingham) to the Midland Junior Gas Association on May 6. The paper was published in the Journal of May 31 (Supplement, p. 593).

The **President** (Mr. J. R. Bradshaw, St. Helens) introduced the discussion.

Mr. **T. Nicklin** (North Western Gas Board) said he favoured the principle of maximum coal throughput of a continuous vertical retort. One thing he had noticed in regard to operating results on vertical retorts over the North Western area was that whereas they could get good thermal yields when making higher calorific value gas, yet they did not seem to get results in therms per ton when steaming down to 450 B.Th.U./cu. ft.—*viz.*, 90 therms/ton with Yorkshire coal.

For example, taking a coal to which Mr. Brown had referred he had shown 78 therms of gas at a calorific value of 500 B.Th.U./cu. ft. Then he would guarantee that if that coal was steamed down to 450, and he wanted to get 93·5 therms/ton, he would not do so. Therefore, why was it so difficult to get 93½ therms/ton when working at the optimum rated throughput of the retort? Getting 93½ therms/ton did fall on the line for steaming that particular coal; so, if it did nothing else the operation of maximum throughput definitely meant that coal could be carbonised more efficiently.

He would like to refer to Mr. Brown's figures for coal throughput. He did not think he had been really fair in his paper to the lower calorific values. In another part of his paper he gave the throughput (as 6·17 tons) for gas *ex* retort house, C.V.460. It was to be presumed this was for 62 in. retorts. The optimum throughput when steaming to 450 was 5½ tons/retort/day, and steaming to 460, 5·8 tons/retort/day. He suggested therefore that the thermal yield of 79·25 therms/ton was low, due to the throughput being higher than the optimum throughput for the retort at that calorific value.

Producer and Water Gas Dilution

He would like to refer to producer gas dilution and to water gas dilution of high calorific value gas made by operating retorts at the maximum coal throughput. If they took the maximum coal throughput (say C.V.500) the calorific value of the gas was probably higher than the calorific value would be if all the sensible heat of the coke was taken and utilised for water gas manufacture. On the basis of Mr. Brown's 78 therms, they could make 15,600 cu. ft./ton of gas of C.V.500 and dilute with blue water gas with a C.V. of 290. The amount of 290 gas required made a total mixed gas volume of 20,800 cu. ft./ton of C.V.450. Taking into account coal throughput (*viz.*, 7·15 tons/retort/day 500 C.V.; 5·5 tons/retort/day 450 C.V.), total output per retort per day increased by 30%. It was a fact that with the continuous vertical retort as it was operated from lower calorific values to higher calorific values, the thermal output did tend to increase; so much so that the thermal output at 450 C.V.—he was giving optimum figures—was 515 therms/retort/day. At 500 C.V. it was nearer 500 therms/retort/day. Substantially, it could be said that the thermal output per retort per day was constant with a tendency to increase as the calorific value increased.

There was another point he would like to make in regard to maximum throughput, and that was on the question of liquor. As they were all aware, the liquor produced per ton of coal carbonised was a great problem nowadays. He would say that the volume per ton of coal carbonised making 500 gas would be of the order of 30 gal., and if they came down to 450, of the order of 50 gal. In other words, they would have to get rid of considerably more effluent, and on the price which local authorities were asking for acceptance of this effluent, this was a very big factor.

He agreed with Mr. Brown in regard to the question of retort life. There was also the question of steam. The steam required per retort per day for steaming in the case of the high calorific value gas was of the order of 900 lb., whereas it would more than double itself when steaming down to 450. Steam, however, was a very expensive commodity nowadays, and, of course, the efficiencies of steam decomposition fell off very badly indeed as the calorific value of the gas in the retort house was decreased.

There was also the question of combustion chamber temperatures. He noticed that Mr. Brown mentioned temperatures averaging 1,360°C., steaming down and on higher throughput. He did not know how anyone could expect to decompose steam efficiently at 1,250°, or less. Low temperature accounted for many therms being lost.

It had been stated there was an increase of coke for sale. This was so in the case of producer gas dilution. What he would like to consider was not the increase of coke from the retort house, but per therm of mixed gas made. With external blue water gas dilution, the coke for sale per ton of coal carbonised was reduced.

Using optimum figures again for the manufacture of 450 gas, the coke available from the retort house per ton of coal carbonised amounted to 10·3 cwt. The coke required to produce blue water gas to dilute the volume of coal gas of C.V. 500 B.Th.U./cu. ft. amounted to 1·65 cwt. giving a net coke for sale figure of 8·65 cwt./ton of coal carbonised. Steaming down to a calorific value of 450, the coke for sale figure would be 9·1 cwt./ton of coal carbonised. Furthermore, on a coke yield per therm of gas made basis, the total thermal output per retort per day with external blue water gas dilution would be 665 therms, giving a figure of 0·093 cwt. of coke/therm of 450 gas. The thermal output per retort per day with steaming to 450 C.V. would be 515 therms, giving a figure of 0·097 cwt. of coke/therm of 450 gas. From the foregoing figures it would be seen that the production of coke per therm of gas for sale was reduced when operating high calorific value gas with external dilution by blue water gas; the increased thermal output of mixed gas being 30%. It must be added that the foregoing calculations were based on optimum working—*i.e.*, 93·5 therm, 450 C.V., steaming down, or 78 therms, 500 C.V., and, as already pointed out, whereas it was possible without apparent difficulty to obtain 78 therms of 500 C.V. gas, it would seem, from a consideration of results obtained, too much to ask 93·5 therms/ton of 450 gas by steaming down.

Mr. **Brown** said he was glad to note that Mr. Nicklin was in general agreement with the principles outlined in the paper and that, broadly speaking, he favoured high throughputs or maximum throughputs with their numerous advantages. Having had considerable experience of the operation of carbonising in vertical retorts over the past 20 years, continued Mr. Brown, he confessed to entertaining a growing doubt as to what really happened in them. Knowledge was very sparse on the subject. He took exception to the simple statement that if there were so many cubic feet of, say, 500 gas, and, like pouring extra water into a pint pot, so many cubic feet of 290 gas were added within the retort, a certain calorific value and a certain number of therms per ton were obtained. It was not a simple arithmetical calculation of two streams of gas, one coming in at one end and water gas at the other.

Personally he was led to believe there were complications arising which threw into doubt the accepted belief that so much water gas could be added to get so many therms of a given calorific value gas. Moreover, it was a doubt which had been suggested also by one or two other people. In a discussion reported in the *Gas Journal*, Mr. Hawthorn, the Divisional Engineer at Birmingham, and Mr. Firth, formerly with the Leeds undertaking, had entered the arena in regard to certain points giving colour to such doubts as he was now expressing.

He was very glad to find that Mr. Nicklin, speaking generally, supported the statements in the paper. The point about inert gas was very important in many districts and he hoped to be hearing further from Mr. Nicklin with respect to it.

He had been reminded about a point concerning water gas dilution of vertical retort gas—namely, that it would have been preferred to use blue water gas externally generated for the purpose; but no water gas plant was available at the works, and the site was too congested to enable such a plant to be installed. To have installed even a straightforward blue water gas plant would have cost a lot of money, and also it would have taken years to install. He thought he would be supported by Mr. Hubbard when he said that he would definitely have

preferred not to use producer gas, but it was a case of high gas demand and it was a solution of the difficulty. It was not to be considered as a permanent solution. The point was that they had not the fuel available and there was not the room to put in the plant. The producer gas was available, and it solved the problem of the high gas demand.

Mr. **M. Redman** (Manchester) asked what was the specific gravity of Mr. Brown's gas when he diluted it to 450 with the producer gas, though it was not to be supposed that any great amount of trouble would arise in regard to it. It was not like diluting horizontal gas with a high calorific value down to 450. Coke was also an important problem. He thought there would be general agreement that they were all engaged in a two-fuel industry, but they did not set out to make coke. They set out to make gas. The fact was that coke was a by-product and it threw upon them the liability to regard the industry as a two-fuel one. Nevertheless, when all was said and done, their job was to make gas. The process of maximum coal throughput could become economical if they could dispose of the coke at a reasonable figure, but it was difficult to do this at the present time.

This raised the question of the flexibility of making gas by the ordinary carbonisation system, and producing coke and using it to make gas. A good way of making gas from coke would be to gasify the coal completely and get rid of the coke trouble. Of course that would depend upon the amount of re-organisation of the industry at the present time, because supplies of cheap oxygen did not seem to be on the way. A second point which was often made was a standard manufacture of water gas and enrichment with oil, but people immediately became frightened because of the price of the oil. Another possible way of enrichment was by the methane synthesis, on the lines upon which the Gas Research Board was working. This might, perhaps, come about, though it might be somewhat costly.

Mention had been made as to what happened in the retort. He suggested that if they did know all about it they would be profoundly shocked at the wastage which occurred. They were producing carbon and degrading it, and they were producing tar, which was another by-product, and they were supposed to be producing gas. They all knew that by introducing steam into the bottom of the retort they produced degradation. It was suggested that they cycle coal gas into the base of the retort in order to improve the efficiency of the retort. It would appear to him that by speeding up that re-cycling they might sweep out the paraffins before they became degraded, and thus produce a tar which might be used for enrichment in a water gas plant when making gas to a reasonably high calorific value.

Mr. **Brown** stated that prior to the admission of producer gas the specific gravity was of the order of 0·48. After the introduction of producer gas it averaged 0·12 or 0·13. The 0·12 brought it nearer to the general specific gravity of the undertaking's gas. At one time the station was out of step with the gas produced in other manufacturing stations as they had carburetted water gas. This introduced a difficulty when gas was pumped from one area to another. The introduction of producer gas brought about a gravity to a more or less constant average. He did not want to be drawn into a discussion on total gasification.

Variations in Quality

Mr. **H. N. Dann** (Blackburn) remarked that the author had mentioned that producer gas was resorted to in order to keep the home fires burning, but had he thought about the effect of varying quality? A case could be instanced where the gas was used for the same purpose that Mr. Brown had used it in order to maintain a supply to the district. The application was, perhaps, specialised. In the case of a factory in Blackburn the application was to spoil a process of making radio valves. The waste from the process rose in one afternoon from the usual 5 to 7% to as high as 45%, with the result that the shop was shut down, and he was sent for to give an explanation. Upon going into the matter he came to the conclusion that possibly producer gas had something to do with it, so the producer gas plant was shut down. A water gas admixture was maintained and no further trouble was observed. After investigation had taken place resort was made again to producer gas dilution for a limited period, and the spoil went up to 30% odd. The producer gas plant was shut down immediately. The next day everything was all right, and there was no trouble when diluting with blue water gas and not producer gas. It was necessary to know the specific purpose for which the gas was to be used.

Mr. **Brown** asked whether he was right in interpreting the circumstances mentioned by Mr. Dann that different combustion characteristics led to the excessive spoilage. He thought he had already expressed the view that dilution should be with blue water gas rather than producer gas, which contained a high percentage of hydrogen and had a high gravity. It was something which should not be used unless there was no alternative, and in his own particular case there was no alternative and the output was required.

Mr. **F. Bell** (Liverpool) said he had some knowledge of the state of affairs that Mr. Dann had mentioned. It was possibly a very special case, and would probably apply to only one or two undertakings in the Division. So long as the pressures were right for general domestic and industrial consumption, then the variation of specific gravity, and therefore the variation of A.T.B. No. should be in line, without any interference with the consumer and the appliance. The gas could be distributed anywhere to 240,000 consumers.

Mr. **Dann** said he was aware that he had referred to a special case. In Liverpool it was possible to run a works on base load conditions, apparently for years. But most of them could not run works on base load conditions; they had to accept the plant they had, and that plant had to be used both winter and summer. There were conditions which would compel them, like they did Mr. Brown during the past few years, to employ makeshifts.

Effect on Producers

Mr. **W. P. Smith** (Rochdale) said the paper would be of great assistance to all gas engineers. One set of figures had given him rather a shock in regard to the calorific value of the producer gas and the variations stated in the paper. They started off with a figure of dilution, the calorific value varying from 95 to 115 B.Th.U., and, finally, in one of the later tests a figure of 134 B.Th.U. was shown. These were large variations. He was not attempting to criticise, but he did suggest that it behoved them to be careful when considering the effect it was likely to have upon producers, particularly if the producer, to start off with, was ample in capacity.

Mr. **Brown** remarked that Mr. Smith had raised a point about the base load working affecting the comparison between the three tests which were enumerated. He would suggest that as the comparison was made on those tests alone, and the comparative net make costs were worked out on those figures, it was questionable whether or not the base load did enter into consideration. It would be noticed the test was for seven days under conditions of normal throughput. Then at some other stage, sooner or later, there was another test under high throughput, reducing to what was termed moderate steaming. The question was for the plant as a whole and for a number of years.

As far as the calorific value of producer gas was concerned, it certainly did vary considerably when it was on very low load in the initial experiments. There were some terrible 'calorifics', and as he had indicated in the paper there was initiated a sort of vicious circle. As the calorific value dropped the input of producer gas had to be checked until, on occasion, it had to be cut off completely.

Mr. **W. S. Hubbard** (Liverpool) said that working the Athol Street works, normally producing 27,000 therms per day, they were able to produce in the winter another 5,000 or 6,000 therms per diem. Whether there had been an increase in another undertaking was of no importance. They actually changed the throughput on the Athol Street plant because it paid them to do so, and it had nothing to do with the base load factor. Like Mr. Brown he did not think that producer gas should be used; he would much prefer that dilution should be by blue water gas.

The **President** remarked that the repair and maintenance of a carbonising plant could be very costly. He would like to have some idea of the life of a carbonising plant by increasing the calorific value and reducing steaming. The method seemed to be ideal if the life of the lining of a carburetted water gas plant or a producer plant could be increased.

Mr. **Brown** said it was difficult to estimate the life of retorts because the experiment was not yet completed, and it was necessary to make sure that like was being related to like. He had pointed out that the previous experience of retort life should be measured with tons of coal per ton carbonised rather than with gas-making. The previous assessment was made during a difficult period of interruptions due to air raids, labour troubles, &c. Therefore a doubt always arose when comparing the life of a retort setting. It could not be done scientifically, for which there had to be one set of conditions, one type of coal, and another set of conditions on the same type of coal. It could not be done under really ideal laboratory conditions.

Mr. **T. Nicklin** proposed a vote of thanks to Mr. Brown, seconded by Mr. **J. F. Smith** (Leyland).

OPERATION EFFLUENT

Following is our report of the discussion on the paper, 'Operation Effluent,' which Mr. Philip Wedgwood, Production Engineer, Watford Division, Eastern Gas Board, presented at the 117th General Meeting of the Eastern Association of Gas Engineers and Managers on May 5 (Journal of May 17, pp. 457-468).

Dr. **A. C. Monkhouse** said the disposal of effluents had always been a major problem in the chemical industry. Effluents might be in the solid form as in cement works, liquid as in gasworks, or gaseous as in acid or smelting works. The most troublesome effluent from the gasworks was undoubtedly that from the ammonia recovery plant, or from the discharge of crude ammoniacal liquor. The constituents not only increased the work of purification at sewage works but they were in many cases toxic.

It was some 25 years since he first served as research Chemist to the then newly-formed Effluents Committee of the Institution of Gas Engineers. It was interesting to look back to that period. Considerable pioneer work had been undertaken by the then Chief Alkali Inspector, Dr. Lewis Bailey, whose death on retirement occured last year. The industry owed Dr. Bailey a great debt of gratitude, because not only did he work out with Mr. Linder methods of analysis, a most important factor in any investigation, but he also surveyed the different methods of carbonisation and their influence on the liquor constituents.

Other pioneer work was done by Adern and Lockett, and others, on how the constituents of ammonia liquor influenced sewage purification. Much knowledge was available. There were two new factors, the growth of the gas industry, and the growth of the use of vertical retorts. Where gasworks and sewage works served equivalent areas, and the spent liquor was from horizontal retorts, there was little trouble. Where, however, the gasworks covered a much wider area, or where the sewage works was under capacity, some difficulty arose.

The Greatest Problem

The greatest problem, however, was the effluent from vertical retort liquors. Not only were they much higher in their oxygen absorption value—the sewage manager's yard stick—but they gave a reddish colour to the inflowing sewage, and what was worse gave in many cases a weak tea colour to the sewage works effluent. The higher tar acids, which were largely responsible for the formation as a result of oxidation of these colour-producing bodies, were a tell-tale of the discharge of ammonia liquor and brought the subject of gasworks discharge to the notice of the sewage authorities.

That was the background. We had not advanced greatly in our knowledge of the various constituents of liquors and their formation, but we had advanced greatly in developing processes for their removal and in acquiring a wider knowledge of how they influenced sewage purification processes. The development of processes for removing phenol was well worked out. Methods for the separation of tar and liquor by hot detarring were available. Each works had its own individual effluent; a function of the type of coal carbonised, the methods of carbonisation, the methods of ammonia recovery, the system of sewage purification, and so on. Each undertaking had to work out its own scheme and ascertain what it would cost. Mr. Wedgwood had brought out the fact that much knowledge was available and that such knowledge must be more widely applied.

The author did not appear to favour the system of removing the tar from the hot gas and keeping the vertical retort tar from mixing with the ammonia liquor. He had made some references to experiments at Coventry in which, by using the existing cyclone tar extractor and modifying slightly the flow and storage of tar and liquor, it was possible to aggregate the vertical retort tar and so reduce the proportion of higher tar acids in the ammonia liquor. The effluent from the ammonia still was reduced from 900 to 714 parts of oxygen absorbed per 100,000, and what was more important, the higher tar acids were reduced from 75 to 29, calculated as grammes of oxygen absorbed per 100,000. Mr. Wedgwood had asked if this was worth while; his view was that it was, because it was a much more acceptable effluent to the sewage works.

The second point to which he wished to refer was the question of volume. The sulphate of ammonia plant at Coventry worked intermittently, as did most sulphate plants, and only over long periods was the flow a function of the ammonia liquor production. He had looked at the original report and he thought Mr. Wedgwood had omitted one month, when the plant was idle, in his comparison of the second period. He should consider 10 months, not nine, in which case the flows in the two periods were more comparable. The volume of ammonia liquor was bound to vary according to the amount of coal carbonised, even if other factors remained constant.

The 'Difference' Figure

He agreed that the 'difference' figure in an O/A determination was a figure which contained other items than higher tar acids, and even if these were wholly removed there would still be a 'difference' figure. Mr. Wedgwood had discussed the amounts of monohydric phenols. These phenols distributed themselves between the tar and liquor according to their solubility coefficients, when the two condensed together. Roughly 50% appeared in the liquor and 50% in the tar. If one took a high phenol liquor, condensed after hot detarring, and shook it up with the tar, the phenol content of the liquor went down and the higher tar acids went up. The whole subject was very complicated and many factors had to be taken into account.

Mr. **Wedgwood** expressed his gratitude to Dr. Monkhouse for dealing with the question of volumes at Coventry; the information was very useful.

Mr. **K. B. Meggitt** (Bedford) said the paper was of topical interest and he had no doubt they would have to take greater precautions in the future because of the more stringent regulations likely to be applied. He observed that Mr. Wedgwood had not advocated hot gas detarring, whereas Dr. Monkhouse had evidently been favourably disposed. He was under the impression that with hot gas detarring the monohydric phenols were increased and the colour-producing factor decreased in the resultant spent liquor which for that reason was more amenable to treatment. The coloration question was important because his experience had led him to believe that many of the complaints received did not affect the main question of toxicity but arose mainly on the coloration question. He took it that a reduction in the higher tar acids would tend to eliminate the discoloration effect. He felt the third part of the paper would be of extreme value to works engineers in that it would enable them to check up on their processes with a view to obtaining a less objectionable effluent than they were at present producing.

Spraying on Growing Crops

Mr. **K. R. Mortimer** (March) said reference had been made to using raw liquor on lawns and he suggested that experiments in that direction in the Eastern area, being largely agricultural, might help the smaller works considerably. He recalled seeing a small works in Rutlandshire where the liquor was sprayed on the land by means of horse-drawn spraying tanks about November, the land not being sown until the spring. In recent work no ill effects had been found from using the liquor on actually growing crops. In some places gas liquor was being sprayed on to town refuse banked over a fairly large acreage. He thought there would be some oxidation effect but he did not know what was the whole effect of the passage of the liquor from the top of the refuse until it finally reached the bottom soil. He asked whether there was any hope of getting sewage authorities to work on the B.O.D. figure instead of the O/A figure. The B.O.D. was a considerably fairer basis.

Mr. **C. B. Staniforth** (Ely) said most people started by seeking to reduce the quantity of ammoniacal liquor made or by consuming as much on the works as possible. As continuous vertical retorts were such heavy offenders one could start there by reducing steaming to 5%, especially if 500 B.Th.U. gas was being made, completing dilution with producer gas. This had the added advantage that not only was less liquor made and a greater percentage of steam decomposed, but the demand for retort steam was usually within the limits of exhaust available

from steam-driven fan engines on waste heat boilers or from exhausters on pumps which needed only to work at about 5 lb. per sq. in. back pressure. In that way no fuel was expended on steam to retorts; likewise little extra heat was drawn from the retort walls to finish the decomposition of this small quantity of steam which had already begun in the coke box and lower end of the retort.

This system increased the gas-making capacity of the plant while the resulting gas was probably as cheap as, or cheaper than, that obtained by heavier steaming involving fuel to boilers, unless such fuel was only coke dust. Another obvious result was the reduction almost to zero of the fresh water going to the final ammonia washers. Evaporation of gas liquor was difficult. They had tried it on producer grates but the stokers objected. The system periodically became choked with tar and some gas liquor escaped untreated to the sewer. He would not risk it as a quenching agent lest it should give the coke an offensive odour, damage the continuous vertical retorts and in general pass to the sewer only slightly de-ammoniated.

Fish Mortality Rate

For some time at Ely they ran their liquor on to a spare part of the works ground in a soak-away, but trees and grass in surrounding property were damaged. Some undertakings were fortunate enough to be allowed to cart their liquor and spread it over the town rubbish dump where it was likely to do more good than harm, but the Ely Council would not permit that, nor would they take the liquor into the sewers on any terms. Running crude liquor direct into streams or water courses was fraught with dangers. At Ely they had been accused of contributing to a high rate of mortality among fish in what was regarded as the best coarse fishing river in the country; they had also been blamed for allowing tar particles to run into the river and spoil the white-painted hulls of pleasure craft. They had long since given up allowing gas liquor to enter the river, but so strict were the Fishery Board that the Ely Council would not accept gas liquor into the sewers in regulated amounts for fear of lowering the standard of their own effluent to the river.

A little over three years ago the Fishery Board's inspector called him down to the river to view the corpse of a solitary fish which had been seen floating near the entrance to a culvert down which flowed effluent—not gas liquor—from the gasworks and other premises. By the time he arrived the fish had floated away, but he was accused of killing the fish—only one, compared with the thousands that were eaten by other fishes or caught by anglers. A few days later the Ouse burst its banks and thousands of millions of gallons of water poured over the Fens. Had he emptied all his gas liquor wells the pollution would have been less than 0.001%. A practice to be guarded against was that of taking samples of effluent without a member of the gas staff being present to see the procedure or to take a companion sample.

The danger of discharging even small quantities of effluent into dykes, ponds, or soak-aways was that it might eventually reach a river or pollute a source of drinking water. After a thorough search of the neighbourhood around Ely he had been lucky enough to find a disused marl pit not known to connect with any stream, and as it was a long way from any houses and fenced off from animals he had discharged surplus liquor into it. Although he was in an agricultural area with fields at his back door it remained doubtful whether it was cheaper to deliver and distribute free gas liquor on the land or to buy a much more concentrated sulphate and spread it, always assuming that gas liquor was beneficial.

Such form of disposal was highly seasonal and one would need considerable storage capacity to hold a year's make. With the co-operation of the Chairman of the former gas company and owners of a number of farms near Ely he took most of his annual product of liquor by road tank and sprayed it by means of pumps on to the manure heaps scattered about the farms. It was claimed that it rotted down the straw more quickly than otherwise, thus allowing it to be absorbed into the earth when the farmer came to 'mucking' the fields; otherwise neither good nor bad effects have been observed. This method of disposal cost about 7s. 6d. to 10s. per 1,000 gal. It seemed to him that the only possible methods of disposal were either by concentration, using a small continuous automatic plant and exhaust steam, thus costing nothing in labour or fuel, or by compelling the local authorities to take the liquor. At Ely the dry weather flow of the sewage plant was 300,000 gal. daily and the make of gas liquor from 500 to 1,000 gal., or about 0.2% which in a regulated flow would only increase the O/A figure by about 15%.

Mr. **Wedgwood** said that the question of hot gas detarring was one on which they could come to a fairer conclusion when they knew something more about the actual constitution of the higher tar acids. If they proved to be mainly catechol then he did not think there would be much advantage in hot gas detarring. A lot of work had been done by the low temperature people, but there were so many uncertainties that he thought they must await more information. Mention had been made of the effect of hot gas detarring in reducing the coloration. At the St. Albans works they had continuous vertical retorts and at times their concentrated liquor plant was too small and they built up stocks until they were almost black. Larger plant was installed and after it had been going for some time the liquor became a pale yellow, and it remained so today.

Reference had been made to putting raw liquor on the land. On that point he would offer one warning—it should be spread evenly and if the farmer had any liquor left in the tank he should not empty it into the ditch. He shuddered to think of the possible consequences of spraying liquor on to town refuse. There might be a reduction in toxicity, but he did not at all like the idea of the liquor passing from the ground underneath the refuse to nearby water courses or sources of supply. He agreed that the B.O.D. standard was preferable to the O/A, because the quantity of gas liquor in sewage was not great. With regard to the question of steaming in retorts there had been some recent correspondence in the technical Press, notably Mr. Firth's letter in the *Journal* of April 26. He thought there had been some changes in heat balance in vertical retorts since they had been re-designed in recent years and the matter was worthy of re-examination. Mr. Staniforth had mentioned that he had discharged liquor into a marl pit some distance from the works. He imagined that in such a pit the liquor would hang about for a long time, and he wondered what would happen if someone eventually came along and put a road or a factory on that site.

Mr. **F. A. Rhead** (Peterborough) said the author had called attention to the effect of hot coke and hot refractory surfaces on the breaking down of phenolic bodies; his findings seemed to call for lighter charges in horizontal retorts, and that was not in keeping with modern practice. It would therefore appear that for economic reasons the solution was not to be found in dealing with the manufacturing side. Not all the water from the works should be regarded as effluent, and he was glad to notice that a distinction had been made in regard to clear water from the condensers. One inch of rain over the area of a normal sized gasworks represented some 36,000 gal. which, if counted as effluent, would increase the total enormously. There was great need for close co-operation with the local authorities.

Mr. **Wedgwood** said the answer to Mr. Rhead's question about lighter charges in horizontal retorts was that they wanted retorts as full as possible. A classical case was that of the old South Metropolitan Gas Company, whose high thermal yield and high rate of cracking was probably due to the fact that their retorts were as full as they could get them.

Mr. **R. J. Gavin** (Royston) said that one advantage of the new set-up of the gas industry was that the smaller works were now able to get the assistance of chemists from headquarters. He had been interested in the suggestions put forward for using liquor on the land and the difficulties experienced in distribution, and he recalled that 25 years ago, when fertilisers were expensive, a very conservative farmer in his area used to go to the gasworks and buy thousands of gallons of ammoniacal liquor and spray it on to his compost heaps.

On the proposition of Mr. **R. A. Weston** (Norwich), seconded by Mr. **R. Whiting** (Ipswich) a vote of thanks was accorded to the author, who briefly replied.

In Table II of Mr. Wedgwood's paper (*Journal* of May 17, p. 464) the columns of figures should be headed, left to right, as follows: Grains/100 cu. ft.; CO_2, H_2S, HCN, and NH_3 under 'Percentage'; Ounce Strength of NH_3.

MINIMUM OF RED TAPE IN WALES GAS INDUSTRY*

By DARRELL W. REES, M.B.E., M.Inst.Gas E.

Engineer and Manager, Pembroke

CONDITIONS have varied possibly more over the last two or three years than at any other period during the long history of the industry. The past, for me, has been of employment under two different owners: the former a municipal authority, the latter a private company, and the present employment in a nationally owned gas industry. These changes have affected many gas engineers. However, when closely reviewed, there is no material difference; the gas engineer is usually concerned only with service to the industry.

The advent of nationalisation was looked upon by many gas engineers with a certain amount of misgiving. They did not know how the change in ownership would affect them, but I think it can be fairly said that this change, although it may have caused a little anxiety and apprehension at the time, has now smoothed itself out and in point of fact, employment in its present form is little different from that which it had been in the past.

I feel that we in Wales should be particularly pleased with the way the administration of the industry is carried out. It is an administration with far less red tape than was originally envisaged, and with more control left in the hand of the individual engineer than I, at least, thought would be.

Anxiety Dispelled

The group system of operation is without doubt a sound one, whereby each and every member of that group has some say in the running of his own undertaking and is in a position to give and accept advice from his engineering colleagues.

Before the group system was put into operation in the Wales Gas Board area I had no idea as to what form the administration was to take, and we must all have been, to say the least, a little concerned about our future positions. Any anxiety which might have been felt at that time has been completely dispelled. I am confident that the gas engineer in Wales is now working happily with the full knowledge that he is an essential part of a complex system which depends so much for its ultimate success upon the contribution that he makes.

We gas engineers are proud of the title, and particularly anxious to see that the engineer is at all times the leading actor in a place of importance, as he should be in any engineering industry. We have to look upon ourselves now not as engineers of several separate undertakings, but as being an integral part of a vast industry, and should submit our loyalty to that industry, which in this case, is the Wales Gas Board.

As each and every engineer is prepared to play his part in this large concern, it is right that similar facilities regarding buying and selling should be available to all, and it is pleasing to see that various forms of standardisation of sales policy are now being put into operation.

I have spoken of the misgivings of engineers regarding their outlook some while ago, so it is only fair that improvements of conditions of service should also be mentioned, and to those who were not participants in any benefit schemes the board's announcement of a proposed superannuation scheme for their officials has been to many of us a great comfort. It is true to say that only by good conditions of service and freedom from fear of want in old age is it possible to obtain from any operative that spirit of co-operation and endeavour which must be forthcoming if the industry is to prosper.

*Presidential Address to the Wales and Monmouthshire Association of Gas Engineers and Managers, Tenby, May 19, 1950.

In the years betwen the two wars there was a general tendency towards some form of functional and geographical integration.

Functional integration was being brought about by large gas corporations and holding companies who saw benefit in grouping together smaller works, who, through commodity high prices, shortage of labour, and very often lack of a high degree of technical control—so necessary to the proper functioning of a gas undertaking—found it impossible to compete with the bigger works who, by the use of modern large scale plant—whereby the labour employed to fuel used ratio was kept low—were able to sell gas at reasonable prices.

Where the undertaking was geographically situated so as to be near to a large undertaking, trunk mains were laid which had the benefit of not only allowing the smaller undertaking to supply gas at a cheaper price than it had hitherto done, but also enabled the larger undertaking, by virtue of the fact that its output had increased—and this usually at little extra charge to its administrative establishment—to manufacture gas cheaper than before.

Effects of Integration

The fear that integration may mean less employment is unfounded. A slight change in the general duties of the manager of the smaller undertaking and his staff is inevitable, but as in the end integration generally means a supply of cheaper gas to the public, integration can prove to be nothing but good.

You will no doubt have heard the announcement by the Chairman of the gas board when he spoke to the gas consultative council at Swansea some months ago, to the effect that it is proposed to integrate gas supplies in the Pembrokeshire group. Since that time I have been examining the possibilities of a trunk supply to Tenby and Saundersfoot, and en route to the villages of Lamphey, Freshwater East, Jameston, Manorbier, and Penally.

The project was outlined many years ago by the Directors of the Pembroke District Gas Company, and at this time I wish to pay tribute to my past Chairman, Mr. W. Clark Jackson, who made every endeavour to promote this scheme. I well recall a meeting with the Directors of the Tenby Gas Consumers' Company in 1944, when this matter was discussed, but the difficulty of carrying out the work during the war period was such that the scheme had to be postponed for the time being.

That a pipe line would ultimately be established between Pembroke Dock and Tenby was always uppermost in the minds of the Directors of the old Company; it prompted them to ensure that adequate gas-making plant should at all times be available to enable this project to be brought about. The present output of gas from the Pembroke District undertaking is approximately 450,000 cu. ft. per day; this increases at peak winter loads to approximately 500,000 cu. ft.

The carbonising plant constitutes 14 vertical retorts with a maximum daily output of not less than 850,000 cu. ft., or a nominal daily output after allowing for scurfing, of 700,000 cu. ft. per day. It is evident, therefore, as far as Tenby is concerned with a maximum requirement of 130,000 cu. ft. per day in the summer time, that the load could quite easily be undertaken by the Pembroke District undertaking.

The scheme becomes more attractive when one considers the fact that the areas to be supplied are those catering for the tourist trade, thereby ensuring a maximum consumption of gas during the summer period, as Pembroke Dock is an indus-

trial town, where the normal maximum demand for gas is in the winter time. This new consumption would have the effect of levelling out the 'load factor' at Pembroke Dock, and thereby still further increasing the manufacturing efficiency which at present is as high as 78%.

The final outcome of a scheme of this description would be to make the present gasworks at Pembroke into a medium-sized gasworks producing somewhere in the region of 300 mill. cu. ft. per annum, which would be a more efficient production station than that which at present exists.

It is also envisaged that at a later date further integration should take place in Pembrokeshire, namely, the linking up of undertakings on the north of the Milford Haven, such as Milford Haven and Haverfordwest.

Gasworks Development

Gas in Pembroke dates back to the year 1853, but it was not until 20 years later that a Provisional Order was obtained by Mr. J. R. Cobb, a solicitor of Brecon, who later formed the Company known as the Pembroke Docks and Town Gas Company, Ltd. The Company operated under that name until 1919, when an Act of Parliament was passed altering the name to the Pembroke District Gas Company.

The limit of gas supply under this Act was the Borough of Pembroke, comprising both Pembroke and Pembroke Dock, and the neighbouring parishes.

The two townships of Pembroke and Pembroke Dock, which lie approximately two miles apart, are entirely different in history and character. Pembroke is an ancient town which grew up in the shadow of the great castle, and served as the market for the rich agricultural lands in the south of the county. Over the years the character of the town of Pembroke has changed little, and it still owes its importance to the fact, that because of its rich soil and mild climate, the production of vegetable crops is earlier than in most parts of these Isles.

Pembroke Dock is a very new town in comparison with Pembroke. Building started in the early part of the 19th century or, to be more precise, in 1814, when the Admiralty established a Royal Naval Dockyard. The Pembroke Dockyard was famous for nearly 100 years as the birthplace of fine ships, one of the best known being the Royal Yacht 'Victoria and Albert,' which, they say, was built at Pembroke Dock to ensure that the finest workmanship was employed as the town was well known for its craftsmen. In the year 1889 a most unfortunate incident took place at the launching of this yacht, and it was with difficulty that she was prevented from capsizing. This was due, some said, to the extraordinary amount of ornamentation that was on her top sides, but others will have it that it was due to the fact that when the calculations for displacement were being worked out the year 1889 was inadvertently included in these calculations.

The town prospered until the early part of the 20th century, but from the end of the first world war the 'Sword of Damocles' was hanging over it, and in 1926 the blow was struck. The announcement that the dockyard would be closed down as a measure of economy after the general strike brought the prosperity of the Borough to an end. After that time, and until the 1939 war, the Borough was classed as a 'depressed area.'

Between the Wars

The Gas Company was largely owned by the family of the late Mr. G. E. Wheatly Cobb, of Caldicot Castle, famous for his interest in the training ships 'Foudroyant' and 'Implacable' —the latter of which was recently in the news when it was sunk in the English Channel earlier this year. Although within a 'distressed area,' the Company had always operated at a reasonably high efficiency, and even through the depression years good dividends were recorded, while at the same time the works was maintained in good condition. Mains and services were extended, and long before the present time saturation of consumers' needs was very nearly reached.

In 1924 the Company erected a setting of Glover West vertical retorts. At that time vertical retorts in so remote an area as Pembroke were, to say the least, something of a novelty, but the benefit of this modern form of carbonisation served the Company well. New offices and showrooms were opened, and one can fairly claim that few undertakings of the size of Pembroke are in possession of showrooms which are so effective and have such advertising value.

The Last Ten Years

The outbreak of war in September, 1939, marked a new chapter in the history of the Company. Pembroke Dock, with its ship re-fueling oil tanks, its barracks, flying boat station, and its re-opened dockyard as a repair base, was a legitimate target for enemy bombers, who found it within easy range of the over-run French coast, where airfields had been established. The air raids started early in the war, the first one being in June, 1940, when bombs were dropped in the vicinity of the dockyard. The first big raid on industrial targets, however, occurred in August, 1940, when the oil re-fueling tanks received a direct hit.

At that time 11 oil tanks, having a total capacity of 110,000 tons, were set ablaze, and were not extinguished for nearly three weeks, and so great was the fire that it was visible from the Devonshire coast. It has since been recorded that this was the largest single fire ever to blaze in Great Britain up to that time. One can imagine the anguish of the people of the small town of Pembroke Dock during those days.

In 1941 the enemy made Pembroke Dock a particular centre of interest; for a town of its population the percentage of casualties was as high as any town in Britain. It was, however, on the night of May 12 and 13, 1941, that the gasworks and district received a terrific bombardment; the large gasholder received a direct hit and there were 15 major breaks in the main distribution system.

For the next two years the difficulty of mantaining supplies of gas was, indeed, great. The output of the Company at that time was approximately 300,000 cu. ft. per day, which had to be distributed with one small gasholder of 40,000 cu. ft. capacity. At peak load periods every available piece of gas-making plant had to be put into commission, and immediately the load decreased at lunch time the plant had to be shut down to a minimum.

Some idea of how difficult an operation this was may be gained from the fact that in the morning between nine and one the amount of gas sent out reached a figure of 160,000 cu. ft., while at night it dropped as low as 30,000 cu. ft. A high standard of efficiency had to be maintained to continue supplies under these adverse conditions, and it was, therefore, necessary to ensure that all mechanical plant, such as exhausters and extractor machinery, was in first-class order, for a breakdown would have resulted in the gasholder being quickly exhausted; this, you will appreciate, would have taken only one hour on a Sunday morning.

The Company after the 'blitz' seized the opportunity of bringing the works thoroughly up to date, and improving the lay-out which had always been somewhat cramped. There was ordered a new set of vertical retorts to replace the 32 old horizontal retorts, and the new vertical retorts were equipped with all modern coal handling plant, and at the same time the opportunity was taken of completely electrifying the works. As the public electricity supply was so expensive, it was decided to generate all the electricity required with diesel engined generators. Later an activated carbon benzole recovery plant was installed, and all the ancillary plant brought up to modern-day standards.

Having pursued such a bold and forward policy during the war, the Company on the coming of peace pressed on still further with its development programme.

When the property of the old Company passed to the gas board on May 1, 1949, the Directors had the satisfaction of knowing that as a result of prudent administration they were handing over a first-class business in first-class order—which was, of course, as it should be—but they also had the additional satisfaction of knowing that as a result of looking forward

during many difficult years the Pembroke gasworks had the capacity to meet any demands which might be reasonably expected to be made upon it over the next four or five years.

Restoration of Industrial Economy

The need for new industry in Pembrokeshire is very apparent. The population in Pembrokeshire has steadily declined through the 20th century and particularly since the year 1926 when, as I mentioned previously, the Naval Dockyard closed down, which meant a loss of employment to some 2,000 men.

The population of the Borough of Pembroke was 15,472 in 1929, 12,000 in 1931, and 10,950 in 1947, a decrease of approximately 30%.

This decline in population has a very serious effect upon the social obligations of the community. It must be appreciated that in the Borough of Pembroke, for instance, roads, sewers, water mains, gas and electricity supplies, and all the necessary amenities were planned for a greater population than which at present exists, and for a reduced population to have to continue payment for these services proves a very heavy burden.

If there is one factor which causes more concern in Pembrokeshire than unemployment it is the loss of the civilian population through migration. Data extracted from the Annual Statistical Reviews of the Registrar General show that in the period between 1921 and 1938 in Pembrokeshire there was a total net loss of population of 13,000.

The greatest loss to the civilian population in Pembrokeshire occurred about the year 1935-1936, when all the young ablebodied men of the area left for the new industrial centres that were springing up on the outskirts of London.

At that time when representation was made for the establishment of industry in the area, those in authority in Pembroke were told 'You have no unemployment problem,' and in fact the Labour Exchanges showed this to be the case at that time. What, however, must be remembered is that the flower of the youth of the Borough had been transported to employment in other areas and all that remained in Pembroke Dock were the children, middle-aged and old-age pensioners.

The future of the county depends very much upon the balance of industry being preserved. The present basic industry in Pembrokeshire is without doubt agriculture, but the establishment of light engineering industries, for instance, would cause a rise in the population which could form a labour pool from which younger people could enter agriculture as well as the other industries.

Without a representative cross section of industry established in Pembrokeshire there is the danger of a progressively diminishing population until ultimately it may be insufficient to support the basic agricultural industry.

It was gratifying to note that in 1945 the Government included the Borough of Pembroke in the schedule of areas which were to be affected by the Distribution of Industry Act, and subsequently two factories have been built within the Borough. These industries are not on a large scale compared with those established in some of the South Wales towns, but we hope they are the beginning of an industrial revolution in Pembrokeshire.

Future of the Association

So much has been said of the past, present, and future of the gas industry, and of the Borough of Pembroke, that it would only be fitting at this juncture to make reference to the past, present, and future of this Association. The past history of the Association is one so illustrious that it would be invidious for me to presume upon the time of the members by trying to recall the highlights in its activities. Several names stand out clearly, but for fear of failing to recall one of them, I refrain from mentioning any.

It is sufficient to say that the Association in the past did great work, in the early stages, when the technical development of gas undertakings was at a low point. It was through the advice of many of our predecessors, together with the help and assistance that they have given, that some of us today are in possession of the technical knowledge so necessary for the progress of the industry.

At present the Association is in its decline, not declining in its general activities and outlook towards the gas industry, but in name only, as the future must almost certainly see the Association formed into a District Section of the Institution of Gas Engineers.

It is very fitting at this time to record that a similar transition took place at the annual meeting of the Association in May, 1909, and by coincidence it was then the privilege of a man from Tenby, Mr. A. H. Brookman, father of the present Mr. F. G. Brookman—who has recently retired as Manager of the Tenby Gasworks—to move that the Wales and Monmouthshire Institution of Gas Engineers should seek affiliation to the Institution of Gas Engineers. Just over 40 years later in the town of Tenby a further development of this theme has been on the agenda, namely, the forming of a District Section of the Institution of Gas Engineers to supersede the old Association. Referring back to the minutes of this 1909 meeting, we find that it was said:

> 'There was a great deal to recommend it and in the interests of the profession and of the industry they [meaning all gas engineers] should all be thoroughly united, the Institution Council was doing good work, and there was no reason why they should not participate in its government and benefits.'

Today the same words can be used. The furtherance of the technical development of the industry is still the primary consideration of the Institution of Gas Engineers, and there is no doubt that closer co-operation between the parent body and the members of the gas industry in the form of a District Section of the Institution of Gas Engineers is, to say the least, highly desirable.

Benevolent Fund

I have spoken at some length on the contributions that are made by members to the technical side of the industry. I now want to refer to the contributions which are being made and, in some cases, not being made, by members to the Benevolent Fund of the Institution of Gas Engineers. The Benevolent Fund is one in which I have taken a great deal of interest, and it is pleasant to record that the appeals in past years by previous Presidents have been successful. I make no apology at the present time for asking you once again to contribute generously to the Benevolent Fund, whose activities over recent years have been such as to relieve distress in many cases. I appreciate that at the present time, with the shortage of money, it is difficult to increase the individual contribution, but I do appeal to those members of the Association who are subscribing to carry on doing so, and to those members who may become members of the District Section of the Institution of Gas Engineers in the near future to subscribe generously to this great cause.

The subscriptions and donations to the Benevolent Fund have increased considerably in the last few years. The sum contributed in 1949 was over £3,000, but it is sad to relate that out of 2,572 members of the Institution in 1949, only 1,362, or 53% contributed to the Benevolent Fund. What is more serious, however, is the steady decline in the number contributing in the years 1947 and 1948.

I am certain that the number of contributors would be far more if it were possible for them to see some of the tragic cases which the Management Committee of the Benevolent Fund of the Institution has to deal with.

The Benevolent Fund has received great benefit in recent years through members paying their subscriptions by deed of covenant. It is pleasing to record that at the present time over 450 such covenants have been signed. The effect of the deed of covenant is great indeed, as it allows the Institution to recover from the Commissioners of Inland Revenue an income tax refund, which in 1949 represented the sum of over £350.

(Continued at foot of page 668

REINFORCED CONCRETE—continued from page 660

mild steel bars for butt welds must be developed. Last but by no means least the training of site labour was essential. Steel benders and fixers were recognised. Operatives should be trained in the mixing and laying of concrete, and paid in proportion to their skill. Unfortunately there were still many engineers who considered that anyone was good enough for concrete work.

Mr. **W. A. Evetts** (Watford) wondered how many tar and liquor tanks there were all over the country that had conditions similar to those described; there must be quite a few. He suspected that prestressed concrete was the authors' real love. It was still in its infancy, as was shown by the fact that every month they found new systems introduced. He mentioned a bridge in the north of England where the old idea was followed of bringing the reinforcing material to the point where the greatest bending moment took place, and another system in which prestressing wires had been replaced by bars.

Mr. **Rose,** in a brief reply, agreed that it was essential to keep proper site control. If there had been anything lacking in the past it had been in not putting proper thought into design. With regard to the repair of purifiers, this work was done in the 30th year of their life, and it had been anticipated that after 40 years they would be scrapped. He could not say how they would repair purifiers to last another 40 years. The designer must keep close to the site. Nothing short of close contact between the designer and the men on the job could solve the various problems that inevitably arose. As to prestressed concrete being their real love, one reason why they had presented the paper in its present form was that they felt that for their particular problems it offered the best solution, particularly in regard to the avoidance of cracks. The technique for doing those things was well developed, and he thought they should try to develop techniques by which they could carry out that class of work on all the structures normally found on a gasworks.

Mr. **Gedge,** dealing with the bending of prestressing wires, said that in practice they did not make a straight bend for straight wires. They either had the wires in a parabolic shape or slightly arched the beam to get the same effect.

Mr. **L. J. Clark** (North Thames Gas Board), proposing a vote of thanks to the authors, said the subject was extremely wide, and probably the gas industry presented more opportunity for diverse applications than any other. Enormous sums of money were spent on prestressed concrete work for foundations in the former Gas Light and Coke Company as well as in the present North Thames Gas Board; some £750,000 must have been spent on reinforced concrete in the last few years. It was important to see that the designs for such expenditure were correct.

Mr. **H. H. Brown** (Exeter) seconded and said the subject of reinforced concrete was likely to become of even greater importance in the future than it had been in the past.

The **President** (Mr. J. H. Dyde) said the discussion, though necessarily brief because of lack of time, was a complete vindication of their views that such papers were a true field for the District Sections. It was impossible for such a paper to be discussed at a meeting of the Institution. This sort of treatment of the subject demanded wide discussion, and even more time should have been given to it.

REES PRESIDENTIAL—continued from page 667

Unfortunately, the number of subscribers by deed of covenant is still too small. I, therefore, earnestly appeal to all members who have not already done so to take out covenants, by which method the subscription to the Benevolent Fund is so greatly increased without any additional expense to the subscriber.

The letters of appreciation of some of the recipients of grants are in such grateful terms that, if they were made public, I am sure this appeal would receive very tangible support.

In concluding this address, I am grateful to record that the gas board has generously agreed and have, indeed, through their Chairman, promised their fullest support to the Association. I know that I speak on behalf of all our members when I say that the confidence that has been placed in the Association, whose objects, as I previously stated, are to promote the technical advancement of the gas industry generally, and particularly of the gas industry in Wales, will not be confidence misplaced.

GERMAN TAR PRODUCTS

DISCUSSING the prospects for the German coal tar industry in 'Die Chemische Industrie' (Düsseldorf), of May, Dr. E. Moehrle, of the Gesellshraft für Teerverwertung, Duisburg-Meiderich, says that before the war Germany produced about 2 mill. tons of gasworks and coke oven tars a year and kept pace with the output of the industry in the U.K. Present output in the Federal Republic is about 1.1 mill. tons a year and is not likely to show any great increase in the near future. To secure the greatest economic benefits from this tar, says Dr. Moehrle, attention must be paid to alternative and new methods of use either for the bulk products of the industry (pitch and creosote) or the pure chemicals isolated from the higher boiling fractions.

The problem of low temperature coal tars does not exist at the present in the Federal Republic since no low temperature carbonisation plants are in operation, those in being before the war being now located in the Russian zone.

Owing to the drop in the demand in the post-war years, stocks of briquette-quality pitch are accumulating in the Republic and Dr. Moehrle considers that the problem of their disposal will only be solved if their use is permitted for the production of petrol and other oils by the pressure hydrogenation process, though the conversion of the pitch into either pitch coke or graphite are alternatives. Special pitches for use in the building industries have been developed in Germany over recent years and have had an encouraging reception.

Referring to creosote oil, the writer says that good quantities of the German material are being shipped to the U.S.A., but owing to strong competition with U.K. suppliers prices received have not been attractive. In this case, also, resumption of the pressure hydrogenation of creosote oils is advanced as the only means of bringing real stability to the industry. Opportunity also exists for the increased use of heavy tar oils as fuel oils and it is hoped that as the result of recent German research, tar oils, from which no solids separate at any temperature usually encountered, will be produced for sale as fuel oils for domestic space heating.

A comparatively new outlet for heavy tar oils is for incomplete combustion to carbon black, and of late years an oil specially prepared for this purpose has been marketed.

In regard to naphthalene, Dr. Moehrle says that recent developments in German production technique have resulted in the direct manufacture of a naphthalene of exceptionally high chemical purity. For use in the manufacture of hydrogenated solvents (tetralin and decalin) it can be obtained completely free from thionaphthalenes without recourse to the treatment with metallic sodium hitherto employed. Economies in the industry have also been obtained by the direct carriage of the molten pure naphthalene to the works of the users.

WASTE PAPER RECOVERY

The report for 1949 of the Waste Paper Recovery Association, Ltd., an organisation representative of the paper and the board mills of this country, points out that last year, which saw a total of 2.74 mill. tons of new paper and board put into circulation, was marked by the consumption of 770,000 tons of waste paper, with supplies of such waste received by the mills of 781,000 tons. During the first three-quarters of 1949 supplies of waste paper somewhat exceeded consumption, and mill stocks rose from 77,000 tons in January to 101,000 tons in August. By the end of the year, however, stocks had fallen to 79,000 tons. For the current year consumption of waste paper is expected to be over 100,000 tons more than in 1949, and an increase in the rate of recovery is essential if the paper and board industries are not to suffer. Last year 36.5% of the waste paper recovered came from local authorities and there seems to be some case—although in general one wishes to see the removal of those controls still remaining—for the renewal of the interest taken by the Board of Trade during the war years and the immediate post-war years in the collection of waste paper by the local authorities.

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